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tific investigation of anilines, the working out of processes, and the study of the constitution of color, particular regard is to be paid to coal tar distillation and the industrial application of cellulose. Another feature will be an experimental dyehouse. Mr. G. H. Frank, M.Sc., and Dr. Oesch, a Swiss expert, are retained on the staff, and with them will be associated Mr. P. E. King, Lieutenant A. E. Woodhead, M.Sc., Professor E. R. Watson, D.Sc., of Dacca College, and, as outside lecturers, Mr. H. P. Hird and Mr. C. F. Cross, both specialists engaged in allied industries.

DISCUSSION AND CORRESPONDENCE

ATMOSPHERIC TRANSMISSION

TO THE EDITOR OF SCIENCE: On page 168 of your issue of August 4, 1916, Mr. Very is unfair to himself, to your readers, and to me. He points out that the Smithsonian Mount Wilson observations of September 20 and September 21, 1914, indicate greater transparency of the atmosphere for the complete, complex solar beam made up of energy of all wave-lengths the greater the air mass. From this he tries to lead your readers into the conclusion that the atmosphere gradually decreased in clearness during our period of observations. Nobody knows better than Mr. Very of Langley's mathematical proof that a complex beam traversing a medium the transmissive power of which varies with the wave-length must necessarily behave in this manner even though the medium is perfectly homogeneous. Pure water or glass would show the same effect. The transmission would continually increase for each successive layer traversed. This is because the less transmissible rays are continually becoming a smaller proportion of the intensity of the whole complex beam the farther it goes through the medium. If our pyrheliometric observations *had not shown* the phenomenon which Mr. Very mentions they would have proved that the sky was growing clearer. The question then only remains whether the effect they do show is of the right magnitude or not. This is settled affirmatively by the results obtained with the spectro-bolometer.

For monochromatic rays the atmospheric transmission should be constant for all air masses, if the atmosphere neither grows clearer nor more opaque. Our spectro-bolometric work shows that this condition was closely fulfilled on the two days in question, as Mr. Very well knows. Having no comfort from the spectro-bolometric work, he omits mention of it, and tries to carry his point with the uninformed by paradoxing.

Mr. Very, however, draws attention to the increase of atmospheric humidity during the observations as indicated by Fowle's measurements. It may be remarked that between air-masses 11.0 and 7.2 on September 20 no appreciable change occurred. Yet that part of the observations gives the same result as the rest, showing that the effect of such small increase of humidity as occurred during the rest of the morning was negligible. Those who consult the original derivation of Fowle's method of estimating atmospheric humidity, are, however, aware that it rests on laboratory experiments extending only to 5 millimeters of precipitable water. For the exceptionally large air masses occurring on September 20 and 21 it was applied to the estimation of over 65 millimeters. It seems as likely that this extreme extrapolation involved inaccuracy, increasing with increasing air-mass rather than that the atmospheric humidity really increased from 3.3 to 4.0 millimeters during so short a time as the first 8 minutes after sunrise. I therefore incline to think that there was very little or no increase at all in atmospheric humidity on September 20 between air masses 19 and 3, although a small increase from 3.3 to 5.2 is indicated by Fowle's results. Later on there was really a small increase of humidity, but it appears to have been insufficient to produce appreciable error in the solar-constant values as calculated from small air masses.

As to the clearness of the sky at Flagstaff, Arizona, in August, 1912, Mr. Very shows that it was clearer there, at 7,000 feet elevation, than he is accustomed to find it near Boston, but he does not show that it was clear sky at Flagstaff. If it was really exceptionally

clear there at that time, it adds one more to the long list of wonders associated with that observatory.

In regard to the third matter, relating to the transmission of terrestrial radiation, I am quite unable to understand Mr. Very's logic. His mind seems to let through the consideration of rays that rise vertically from the earth's surface, but to abolish all thought of those which rise obliquely. Like every other surface, all parts of the earth's surface emit rays in all directions within a hemisphere, and tend to cool by the loss of the energy of all these rays which they emit. The loss is to some extent compensated by rays which reach the earth from every one of these directions, and which at night come mainly from the emission of the atmosphere itself. Mr. Ångström and others have measured at night the excess of the radiation emitted by a horizontal blackened surface, at terrestrial temperature, over the radiation received by such a surface from above. There is no great disagreement in the observation. All observers find the net loss of radiation at 20° C. to be from 0.12 to 0.20 calories per sq. cm. per minute, depending on the state of the atmosphere. But Mr. Very maintains that the whole of this loss represents energy that is transmitted entirely through the atmosphere in direct beams from the earth's surface to space. I see no reason to admit this at all. What is measured is a difference between the energy of two beams of rays, one leaving the surface, the other reaching it. If the atmosphere (taking its entire thickness) was totally opaque to these rays, there would still be a difference in these amounts of energy, because the atmospheric sources are at a lower temperature than the earth's surface.

To determine the transmission of the earth's surface-radiation through the atmosphere, as I define it, one must sum up the total of all radiant energy which, having been emitted by a horizontal fragment of the earth's surface, escapes outside the atmosphere into space, by whatever path, without having suffered true absorption and re-radiation. The sum total just described divided by the original quantity

emitted by the same element of surface is the transmission. Perhaps Mr. Very has in mind the coefficient of vertical transmission. This is naturally larger than mine, but it does not serve to indicate the rate of loss of heat of the earth's surface by radiation. That depends on the rate of loss by oblique rays as well as that by normal ones.

C. G. ABBOT

MOUNT WILSON, CALIF.,

August 17, 1916

A REMARKABLE AURORAL DISPLAY

BETWEEN eight and nine o'clock on the evening of August 26 I stepped out on the porch of our cottage on the shore of Lake Douglass in northern Michigan and noticed what I at first mistook for an unusually bright twilight for that date and hour.

Looking up through the tree-tops I saw a curious flickering as of sheet lightning on a bit of cloud. But there was a peculiar streaming movement which at once suggested an auroral phenomenon, although I was looking towards the south! Passing around the house to an open field, I was fairly staggered with such a spectacle of light in motion as had never been dreamed of by any of our family group of eight which at once answered my cry of amazement.

Practically the whole vault of the heavens was alive with light. Light in patches, bands and arches; in streamers, sheets and delicate pencilings. Clear from the northern horizon to the zenith, and far beyond until the southern sky was invaded to within about four degrees of the horizon, and was utilized for the unfolding of the display.

I had seen what I thought to be fine auroras much farther to the north, but had never even heard of one which required almost the entire expanse of the heavens for its staging.

The focus of the spectacle was the zenith itself, and around this was a shifting and irregular zone of light below which almost the entire sky was set with masses of shifting, shimmering radiance constantly changing shape as if the sky were a vast kaleidoscope. It seemed, indeed, as if we stood beneath the